UNITED STATES PATENT APPLICATION

For

METHOD, APPARATUS AND SYSTEM FOR A SINGLE CHIP AUDIO SOLUTION CONTROLLER AND DSP

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METHOD, APPARATUS AND SYSTEM FOR A SINGLE CHIP AUDIO SOLUTION CONTROLLER AND DSP

FIELD OF THE INVENTION

[0001] The invention relates to computer audio technology, generally. More specifically, the invention relates to versatile power saving audio technology in computers.

BACKGROUND

[0002] While the CD-ROM device may be used to load software onto a computer (e.g. notebook) it may also be used to play music through that same computer's speaker(s). In recent years the popularity of playing audio files from a computer's CD-ROM drive has grown as the number of people with personal computers and notebook/laptop computers has increased dramatically.

[0003] However, in order to play music it may be necessary to have special software (e.g. Windows media player) installed on the computer to play audio files from a CD. This software has traditionally been accessed by the computer system's CPU. Therefore, it may be necessary for the computer to be powered on and booted up so that a traditional operating system using the computer's CPU can play an audio file from a computer's storage location (e.g. CD-RW, hard drive, SmartMedia, etc...). These requirements can waste time and power by requiring a system to be powered on, booted-up, and for the system to remain in this mode during the playing of audio files. "The wasting of power is a more

pronounced problem in a laptop computer which is running on a battery. All laptops use some type of rechargeable battery (lithium, nickel-cadmium, nickel-metal hydride).

[0004] The battery life varies depending on the type of rechargeable battery (lithium batteries tend to hold their charge longer) and how you use your computer (frequent use of disk drives consumes a lot of battery power). In addition to the main battery, laptops have other batteries to run clocks and backup CMOS RAM. (How Stuff Works by Craig Freundenrich, Ph.D. http://howstuffworks.lycos.com/laptop.htm/printable)

[0005] Referring to Figure **1**, a diagram of a notebook computer system is illustrated. The notebook computer system of Figure **1** includes a microprocessor (also referred to as a CPU) **104** that is coupled to several types of storage systems, such as, a read only memory ("ROM") **109**, a random access memory ("RAM") **110**, a hard drive **111** for mass storage, and a floppy disk drive **112** or drives for storage on removable magnetic floppy disks. The notebook computer system also includes a display (e.g. active matrix display) **113**, manual input devices (e.g. touchpad **101**, keyboard **102**), and communications devices (e.g. modem) **114**. To play an audio file on this notebook **100**, a user would first have to make sure the notebook **100** was powered on and running. Through entries made at the touchpad **101** or keyboard **102** the user can control the playing of audio files from a CD in the notebook's disk drive **103**. However, in order to accomplish this control over the CD-ROM drive **103**, the user's commands must be routed through the notebook's **100** CPU **104**. In order to

process the command at the CPU **104**, the user must have started the notebook's audio software (e.g. Windows media player). The CPU **104** using the notebook's audio software processes the user's request (e.g. play button pushed). If for example the user has pressed the play button, the following takes place. First, the CPU **104** using the notebook's audio software retrieves an audio file from the disk drive **103**. Second, the CPU decompresses the file (e.g. MP3) if necessary. Next, the digital audio data is passed to the notebook's CODEC (e.g. Intel's Audio Codec '97) **105** so that the final digital data from the disk drive **103** may be converted from a digital to analog signal. After converting digital to analog, the analog signal's strength is be increased at an amplifier **106** and sent to the notebook's speaker **107** for output as music.

[0006] Referring to Figure **2**, in the prior art there is a device **201** which would allow the playing of CD audio format files from a Notebook computer's CD-ROM **202** drive while the Notebook Computer **100** is powered off or in a power saving state such as sleep or suspend mode. The prior art system **200** includes the prior art device **201**, a CD-ROM Drive **202**, and Equalizer **203**, a Mixer **204**, an AMP **205**, an Audio Chip **206**, and a CODEC **207**. The device **201** is limited to a single format and this device **201** is not upgradeable or programmable. Such a device does not play the audio. The device **201** is limited to processing requests (e.g. from a keypad) and converting the requests to an ATAPI command. The device **201** then forwards the ATAPI command to a CD-ROM. The CD-ROM is capable of understanding ATAPI commands. The CD-ROM actually plays the song as a result of receiving the ATAPI command from the device **201**. Such a

device is limited to processing requests to play audio files of CD audio format while the attached computer **100** is powered off or in a power saving state (e.g. sleep/suspend). This device **201** does not have the ability to play files of MP3, WMA, or AAC files. Moreover, this device cannot be reprogrammed through a software upgrade to play files of various audio file formats (e.g. MP3, WMA, or AAC). As stated, the device **201** only processes commands and forward those commands to a CD-ROM drive.

[0007] Referring to Figure **3**, we see a diagram of the device **201** covered in Figure **2**. We are told in the prior art that the device known as an audio interface IC **300** includes a state machine **301** as contrasted with a programmable controller. The state machine **301** connects to an SMBus interface **302**, to a register block **303**, to an LCD control **304**, and to a clock generator **305**. Also, the audio interface IC **300** includes control-button logic **306** that receives electrical signals from CD-ROM control buttons. In response to such signals, the control-button logic **306** may store data into the register block **303**, or it may cause a digital volume control **307** to transmit control signals to an audio output amplifier. The audio interface IC **300** also includes a Host IDE interface **308** and an IDE-signals multiplexer **309**.

[0008] What is needed is a device which does not merely pass commands through to a notebook's **100** CD-ROM drive **103** instructing it to play a CD audio file of CD audio format. A device which can read files, a device which can handle multiple formats (e.g. MP3, AAC, and WMA), and a device that is upgradeable by reprogramming the device with software upgrades is needed.

[0009] Another feature which is desirable is the ability to record voice while a computer system (e.g. laptop) **100** is powered off or in a power saving state. Currently, a computer system **100** would need to be powered on and special software controlled by the CPU **104** would be needed to handle voice recording through the system's microphone. Continuing to power the entire system when the user is merely attempting to record voice through a microphone to a disc on the system's disk drive **103** wastes valuable battery **108** power. Furthermore, requiring the computer system **100** to be powered on and to bootup is time consuming.

[0010] As stated above the computer system **100** is powered by a battery **108** with a limited life. By developing a single device which allows for the playing and recording of audio files while a computer (e.g. notebook) **100** is powered off or placed in a power saving state, a significant reduction in power use may be realized. This may increase the battery life on notebook computers. In addition to battery life, time and convenience may be achieved by such a single device solution. Finally, by developing a single device which is both upgradeable and programmable, the single device will have an increased longevity and provide a greater benefit to the user than devices similar to the device in the prior art.

SUMMARY OF THE INVENTION

[0011] In one embodiment, the invention is an apparatus. The apparatus includes a micro-controller. The apparatus also includes an input device coupled

to the micro-controller to receive user entries to control a primary device's audio device when the primary device is in a power saving state. The apparatus also includes an interface or a plurality of interfaces coupled to the micro-controller, the interface or interfaces to provide the micro-controller with access to a storage location or a plurality of storage locations, where the storage location or storage locations are coupled to the primary device. The apparatus also includes a gateway coupled to the micro-controller. The apparatus also includes A DSP coupled to the gateway, the DSP to read user requested files, decode user requested files, and write to user files. The apparatus also includes an output port coupled to the DSP, the output port to transmit a decoded audio stream out of the DSP and receive a digital signal into the DSP.

[0012] In an alternate embodiment, the invention is a method. The method includes recognizing that a primary device with a storage location or storage locations has been placed in a power saving mode. The method also includes switching the ability to access the storage location or storage locations from a primary device to an audio device after the primary device has been placed in a power saving mode.

[0013] In another alternate embodiment, the invention is a method. The method includes searching a storage location for a digital signal processor (DSP) boot program. The method also includes providing the DSP with a boot program. The method also includes searching for updates to the DSP or micro-controller's firmware. The method also includes providing the firmware updates to the DSP and/or micro-controller.

[0014] In an additional alternate embodiment, the invention is a method. The method includes accepting a user request at a keypad, to process an audio file located on a primary device's storage location. The method also includes converting the user request to an entry code. The method also includes transmitting the entry code to an audio device. The method further includes determining the entry code's function. The method further includes locating the audio file on the audio device's storage location. The method further includes processing the audio file.

[0015] These and other features and advantages of the present invention will be apparent from a review of the detailed description and its accompanying drawings that follow.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] The present invention is illustrated by way of example and not limitation in the figures of the accompanying drawings, in which like references indicate similar elements, and in which:

[0017] Fig. **1** illustrates an embodiment of a notebook computer.

[0018] Fig. **2** illustrates an embodiment of a prior-art audio device in a notebook computer.

[0019] Fig. **3** illustrates an alternate embodiment of the prior-art device of Fig. **2**.

[0020] Fig. **4** illustrates an embodiment of the architecture described within a system.

[0021] Fig. **5**a illustrates an embodiment of a method of transferring control of a computer's disk drive to the audio device described.

[0022] Fig. **5**b illustrates an embodiment of a method of upgrading the firmware of the audio device described.

[0023] Fig. **5**c illustrates an embodiment of a method of playing an audio file utilizing the audio device described.

[0024] Fig. **5**d illustrates an embodiment of a method of recording voice utilizing the audio device described.

[0025] Fig. **5**e illustrates an embodiment of a method of utilizing the karaoke feature of the audio device described.

[0026] Fig. **6**a illustrates an embodiment of a method of transferring control from the computer to the audio device.

[0027] Fig. **6**b illustrates a table of the four operational modes described.

[0028] Fig. **7**a illustrates an alternate embodiment of the audio device of Fig. **4**.

[0029] Fig. **7**b illustrates an alternate embodiment of a method for upgrading controller and DSP firmware.

[0030] Fig. **7**c illustrates an embodiment, of a method for upgrading the firmware of the embodiment described through a I2C port.

[0031] Fig. **7**d illustrates an embodiment, of a method for upgrading the firmware of the embodiment described, through a USB port.

[0032] Fig. **8**a illustrates an alternate embodiment of a method for playing an audio file from a primary device's disk drive utilizing the embodiment described.

[0033] Fig. **8**b illustrates a table of the functions associated with each keypad entry.

[0034] Fig. **8**c illustrates an architecture of the embodiment described within a computer (e.g. notebook) audio system.

[0035] Fig. **9** illustrates an alternate embodiment of a method of recording voice utilizing the embodiment described.

[0036] Fig. **10** illustrates an alternate embodiment of a method of utilizing the karaoke feature of the embodiment described.

DETAILED DESCRIPTION

[0037] Embodiments of the present invention (as described below as well as others) may be realized in accordance with the following teachings and it should be evident that various modifications and changes may be made in the following teachings without departing from the broader spirit and scope of the invention. The specification and drawings are, accordingly, to be regarded in an illustrative rather than restrictive sense and the invention measured only in terms of the claims.

[0038] Some portions of the detailed descriptions which follow are presented in terms of algorithms and symbolic representations of operations on data bits within a computer memory. These algorithmic descriptions and representations are the means used by those skilled in the data processing arts to most effectively convey the substance of their work to others skilled in the art. An algorithm is here, and generally, conceived to be a self-consistent sequence of steps leading to a desired result. The steps are those requiring physical manipulations of physical quantities. Usually, though not necessarily, these quantities take the form of electrical or magnetic signals capable of being stored, transferred, combined, compared, and otherwise manipulated. It has proven convenient at times, principally for reasons of common usage, to refer to these signals as bits, values, elements, symbols, characters, terms, numbers, or the like.

[0039] It should be borne in mind, however, that all of these and similar terms are to be associated with the appropriate physical quantities and are merely

convenient labels applied to these quantities. Unless specifically stated otherwise as apparent from the following discussion, it is appreciated that throughout the description, discussions utilizing terms such as "processing" or "computing" or "calculating" or "determining" or "displaying" or the like, refer to the action and processes of a computer system, or similar electronic computing device, that manipulates and transforms data represented as physical (electronic) quantities within the computer system's registers and memories into other data similarly represented as physical quantities within the computer system memories or registers or other such information storage, transmission or display devices.

[0040] The present invention also relates to apparatus for performing the operations herein. This apparatus may be specially constructed for the required purposes, or it may comprise a general purpose computer selectively activated or reconfigured by a computer program stored in the computer. Such a computer program may be stored in a computer readable storage medium, such as, but is not limited to, any type of disk including floppy disks, optical disks, CD-ROMs, and magnetic-optical disks, read-only memories (ROMs), random access memories (RAMs), EPROMs, EEPROMs, magnetic or optical cards, or any type of media suitable for storing electronic instructions, and each coupled to a computer system bus.

[0041] The algorithms and displays presented herein are not inherently related to any particular computer or other apparatus. Various general purpose systems may be used with programs in accordance with the teachings herein, or

it may prove convenient to construct more specialized apparatus to perform the required method steps. The required structure for a variety of these systems will appear from the description below. In addition, the present invention is not described with reference to any particular programming language. It will be appreciated that a variety of programming languages may be used to implement the teachings of the invention as described herein.

[0042] In one embodiment, the invention is an apparatus. The apparatus includes a micro-controller. The apparatus also includes an input device coupled to the micro-controller to receive user entries to control a primary device's audio device when the primary device is in a power saving state. The apparatus also includes an interface or a plurality of interfaces coupled to the micro-controller, the interface or interfaces to provide the micro-controller with access to a storage location or a plurality of storage locations, where the storage location or storage locations are coupled to the primary device. The apparatus also includes a gateway coupled to the micro-controller. The apparatus also includes A DSP coupled to the gateway, the DSP to read user requested files, decode user requested files, and write to user files. The apparatus also includes an output port coupled to the DSP, the output port to transmit a decoded audio stream out of the DSP and receive a digital signal into the DSP.

[0043] In an alternate embodiment, the invention is a method. The method includes recognizing that a primary device with a storage location or storage locations has been placed in a power saving mode. The method also includes switching the ability to access the storage location or storage locations from a

primary device to an audio device after the primary device has been placed in a power saving mode.

[0044] In another alternate embodiment, the invention is a method. The method includes searching a storage location for a digital signal processor (DSP) boot program. The method also includes providing the DSP with a boot program. The method also includes searching for updates to the DSP or micro-controller's firmware. The method also includes providing the firmware updates to the DSP and/or micro-controller.

[0045] In an additional alternate embodiment, the invention is a method. The method includes accepting a user request at a keypad, to process an audio file located on a primary device's storage location. The method also includes converting the user request to an entry code. The method also includes transmitting the entry code to an audio device. The method further includes determining the entry code's function. The method further includes locating the audio file on the audio device's storage location. The method further includes processing the audio file.

[0046] The invention provides, in various embodiments, a method and architecture which may play audio files of multiple formats (e.g. MP3, WMA, AAC) from a primary device's (e.g. notebook computer, audio jukebox, etc...) storage location (e.g. CD-RW, hard drive, SmartMedia), or record voice to a primary device's storage location while the primary device is in a power saving mode (e.g. power off mode, suspend mode, sleep mode, or a similar power saving mode).

[0047] One embodiment described is a low-power, single chip, audio file (e.g. MP3) player with a direct IDE interface to a storage location (e.g. hard drive, CD-RW, SmartMedia). In this embodiment, an MP3 decoder, 8051 micro-controller, ATAPI interface, IDE interface, keypad interface, and CODEC interface are incorporated. This embodiment may be suitable for low-power audio file (e.g. MP3) playback applications such as a laptop while in OFF mode.

[0048] Figure **4** illustrates an embodiment of the architecture described within a system **400**. The audio device **401** described may be implemented on a single integrated circuit or on multiple integrated circuits; the embodiment described is not limited to playing audio files of the CD audio format (e.g., CD_DA) from the computer's storage locations. The architecture of the embodiment described may play MP3, WMA, or the AAC formats. Furthermore, the embodiment described may be modified through software upgrades to handle additional or different audio formats. Also, the embodiment may be used to record voice to a storage location on the computer while the computer is in a power saving mode.

[0049] Referring to Figure **4**, in one embodiment, a computer (e.g. notebook) is coupled to an audio device **401** through the computer's South Bridge **402**. The audio device **401** may be coupled (e.g. through IDE interface **407**) to a computer's disk drive **403**. In addition, the audio device **401** may be coupled (e.g. through IDE interface **407**) to a hard drive **411**. Furthermore, in an alternate embodiment the audio device **401** may be coupled to a SmartMedia **412.** The disk drive **403** may be internal or external to the computer. Figure **5a** illustrates an embodiment of a method of transferring control of a computer's disk drive to

the audio device **401** described. Figure **5b** illustrates an embodiment of a method of upgrading the firmware of the audio device **401** described. Figure **5c** illustrates an embodiment of a method of playing an audio file utilizing the audio device **401** described. Figure **5**d illustrates an embodiment of a method of recording voice utilizing the audio device **401** described. Figure **5**e illustrates an embodiment of a method of utilizing the karaoke feature of the audio device described. An example of karaoke would be to have a user sing along (e.g. through the computer's microphone) to music being output through the computer's speaker while the user's voice is also output through the computer's speaker.

[0050] The following describes one embodiment of the process of transferring control to the audio device **401** included in the system **400** of Figure **4**. Referring to Figure **4** and Figure **5a**, a computer (e.g. notebook) which is coupled to an audio device **401** through the computer's South Bridge **402** is placed **501**a in a power saving mode. Upon placing the computer in a power saving mode, the computer sends a signal to the audio device **401** notifying **502a** the audio device **401** that the computer has been turned off or placed in a power saving mode (e.g. sleep/suspend). The audio device **401** responds to the signal sent from the computer's South Bridge **402** by disconnecting **503a** the computer's communication connection with the computer's disk drive (e.g. CD-RW drive **403**). After disconnecting the computer's connection to the disk drive **403**, the audio device **401** provides **504**a a communication connection between itself and the computer's disk drive **403**. In alternate embodiments, the audio device **401**

communicates with the computer's hard drive **411** or SmartMedia **412** instead of the computer's disk drive **403**. In further alternate embodiments, the audio device **401** may access the computer's disk drive **403**, hard drive **411**, or SmartMedia **412**.

[0051] The following describes one embodiment of the process of upgrading controller firmware and DSP firmware associated with the audio device **401**. Referring to Figures **4** and **5b**, the process begins by powering on **501b** the audio device **401** or by resetting the audio device **401**. Next, the audio device **401** is initialized **502b**. Following initialization of the audio device **401** a check **503b** is made to see if there is upgrade firmware for the audio device's **401** controller or DSP. The upgraded firmware is loaded **504**b to the audio device **401**. After the upgraded firmware has been loaded, the audio device **401** begins executing **505**b the upgraded program. If no upgrade has been provided the audio device's **401** controller enters a housekeeping loop where it monitors **506b** interrupt requests notifying the audio device's **401** controller of firmware upgrades. The DSP firmware performs DSP functions such as MP3 decoding, noise cancellation etc. The controller firmware handles the data transfer and system functions such as IDE data transfer and USB data transfer.

[0052] The next three embodiments of processes cover three functions of the audio device **401** of Figure **4**. The functions covered include playing an audio file (e.g. MP3 format) from a storage location (e.g. hard drive **411**), recording voice or sound input at a computer (e.g. notebook computer) microphone to the computer's disk drive and providing a karaoke feature. Referring to Figure **5**c, an

embodiment of a method for playing an audio file utilizing the embodiment described is provided. Referring to Figures **4** and **5**c, to initiate the audio device's **401** playing of an audio file (e.g. MP3) from a disk drive **403**, the play button on a keypad **404** attached to the audio device **401** is pressed **501**c. In one embodiment, the keypad **404** is a computer keyboard. The audio device **401** receives **502**c a signal that the play button has been pressed and sets up the transfer of an audio file (e.g. MP3) from the computer's storage location (e.g. CD-RW **403**). The audio device **401** decodes **503**c the audio file if necessary. After any necessary decoding the audio file is sent **504**c to the codec (e.g. AC97) **405** which outputs the audio file as sound through a listening device (e.g. computer's speaker).

[0053] Referring to Figure **5**d, an embodiment of a method of recording voice utilizing the audio device **401** described is provided. Referring to Figures **4** and **5**d, to initiate the audio device's **401** recording of voice, the record function on a keypad **404** attached to the audio device **401** is chosen **501**d. The audio device **401** receives a signal that the record button has been pushed and prepares **502**d for the transfer of voice (e.g. received at a computer's microphone) to a disk drive (e.g. CD-RW) **403**. The audio device **401** then begins receiving **503**d the voice or sound input (e.g. by computer's microphone) from the codec **405**. If necessary, the audio device **401** performs **504**d noise cancellation. Furthermore, the audio device **401** compresses **505**d the data if requested. Next, the voice or sound received at the audio device **401** is stored **506**d to a storage location (e.g. hard drive **411**).

[0054] Referring to Figure 5e, an embodiment of a method of utilizing the karaoke feature of the audio device **401** described is provided. Referring to Figures **4** and **5**e, a user would begin playing **501**e an audio file. While the audio file controlled by the audio device **401** is playing, the audio device is capable of accepting **502**e sound input through the computer's microphone. The sound received at the microphone is then amplified **503**e before it is output. After being amplified, the sound is output **504**e through a listening device (e.g. computer's speaker) at the same time as the audio file being played is output through the listening device.

[0055] Referring briefly back to Figure **4**, an embodiment of the architecture described within a system is illustrated. Referring briefly back to Figure **5**a, an embodiment of a method of transferring control of a computer's disk drive to the audio device described is illustrated. Referring to Figure **6**a, an embodiment of a method of transferring control from a primary device (e.g. notebook computer) to the audio device is illustrated. The audio device's **401** interfaces include but are not limited to Host South Bridge (e.g. H_IDE) **406**, IDE disk drive (e.g. C_IDE) **407**, keypad I/O **408**, and CODEC **409** interfaces.

[0056] Referring to Figures **4** and **6**a, the method for transferring audio control from the primary device (e.g. notebook computer) to the audio device **401** is initiated by powering off **601**a the primary device (e.g. notebook computer) or placing the primary device in a power saving mode (e.g. power off, sleep mode, or suspend mode). In response to being placed in a power saving mode, a signal, such as a single wire signal for example is sent **602**a from the primary

device's South Bridge **402** to an audio device **401**, notifying the audio device **401** that the primary device **401** has been placed in a power saving mode. In response to the signal sent from the primary device, all the modules in the audio device **401** are reset **603**a through a global power on reset or other suitable signal.

[0057] In one embodiment of the audio device architecture, the audio device **401** has four operational modes. They are selected during the chip reset through the use of two input pins (e.g. TEST and MODE_SELECT **415** in one embodiment). The four modes are shown in Figure **6**b. In transparent mode **601**b, the audio device **401** is transparent to the primary device (e.g. notebook computer), the IDE signals from the South Bridge **402** are passed directly through the audio device **401** to the disk drive (e.g. CD-RW) **403** and vice versa. The same is true for AC link **409** to the codec **405**. Thus, the audio device **401** remains in the reset state. In DSP mode **602**b, the audio device **401** is used to play audio files (e.g. MP3) and to handle other functions, transferring control of those duties from the primary device (e.g. notebook computer). When the audio device's **401** DSP mode **602**b is selected, after the reset, the controller (e.g. 8051 controller) starts execution from the internal ROM. In one embodiment of the architecture described, the controller is an 8051 controller.

[0058] The built-in 8051 controller is mainly designed to be an on chip host processor for the audio device's DSP. The 8051 serves as the controller for the interface modules such as Host IDE **406**, CD IDE **407**, USB **414**, I2C **413**, etc... Also, the 8051 handles user interface functions. The 8051 controller has a